

REMARKS

Upon entry of this amendment, claims 1-10, 12-22, 24-25, 33-45, 56-86 and 89, will be pending in the application. Claims 1, 4, 10, 17, 21, 33, 41, 44 and 89 are being amended.

Reconsideration of the present application is respectfully requested in view of the amendments and arguments made herein.

Rejections Under 35 U.S.C. § 103

I. The Examiner rejected claims 1-7, 10, 12-22, 33-45, 56-86 and 89 under 35 U.S.C. § 103(a) as being unpatentable over Chiu et al. (US 5,985,092) in view of Satou et al. (US 5,961,850).

Chiu et al. does not teach claim 1, as amended, which is to a method of processing a substrate in which gas is energized by applying an RF current through a multi-turn antenna above an external surface of a wall of the process chamber to pass RF energy through the wall of the process chamber to the gas inside the process chamber to energize the gas. Radiation is directed onto the substrate surface from directly above the substrate and also through the wall of the process chamber. Radiation reflected from the substrate is then detected from directly above the surface of the substrate after the radiation propagates through the wall. The detected radiation is collimated and evaluated to monitor the depth of a layer being processed on the substrate.

First, Chiu et al. does not teach energizing a gas by applying an RF current through a multi-turn antenna above an external surface of a wall of the process chamber to pass RF energy through the wall of the process chamber to the gas inside the process chamber to energize the gas. Instead, as noted by the Examiner,

Chui et al. teaches an etching system, which has:

“...coils formed of hollow copper tubing around the quartz walls of the etching chamber. The copper coils are provided around the etching chamber to provide an RF field to the interior of the chamber, and completely surround parts of the chamber walls. (Column 2 lines 39-43.) [Emphasis added]

A diagram of the etching chamber, as shown in FIG. 1, and the corresponding description further confirms that in Chui et al, the coils surrounds the chamber:

Coils 18 are wound around the walls of the quartz bell jar 12 for applying an electric or magnetic field to the inner chamber to either excite an etchant or to control the properties of an excited etchant....

The coils 18 typically consist of copper or other low resistivity metal tubing wrapped in a shallow spiral around the quartz bell jar...

(Col. 4, lines 50-57). [Emphasis added.]

Thus, Chiu et al. does not teach “applying an RF current through a multi-turn antenna above an external surface of a wall of the process chamber” as claimed in claim 1.

Further, Chiu et al. does not teach directing radiation onto the substrate surface from directly above the substrate and through the wall of the process chamber, detecting the radiation reflected from the substrate also from directly above the substrate, collimating the detected radiation, and evaluating the detected collimated radiation. Instead Chiu et al. teaches that:

Etching operations proceed by introducing or exciting a plasma of an etching gas or gases above the substrate to be etched. The progress of an etching operation can be monitored by tracking either characteristic emissions or absorptions from the materials produced by etching the surface of the workpiece. Other processes, including those listed in the background of the specification, might also be used for detecting the end of a process step. Optical techniques where the endpoint of an etching process is identified by detecting a variation in an optical signal are preferably used in embodiments of this invention to monitor the etching process. (Column 5, lines 7-23.)

Thus Chui et al. teaches tracking emissions or absorptions from the materials produced

by etching and does not teach directing radiation onto the substrate surface from directly above the substrate and through the wall of the process chamber, as claimed in claim 1. In the background section, Chiu et al. further teaches various endpoint measurement techniques, which include "monitoring the intensity of fluorescence or characteristic emissions" (Col. 1, lines 62-63). However, such emissions are generated by the plasma or fluorescence of the material in the chamber, and do not comprise radiation directed into the chamber and subsequently detected as reflected radiation, as claimed. Chui et al. also teaches techniques involving optical absorption, ellipsometry, and reflectance measurements. (Col. 2, lines 1-17). However, while Chui et al. teaches different types of endpoint techniques, Chui et al. does not teach or suggest directing radiation onto the substrate surface from directly above the substrate and through the wall of the process chamber and detecting radiation reflected from the substrate. Chui et al. also does not teach collimating the detected radiation and evaluating the detected collimated radiation, as claimed, which provides a better signal to noise ratio for the detected reflected radiation.

Applicants submit that Satou et al. cannot be combined to Chui to make obvious claim 1. Satou et al. does not make up for the deficiencies of Chiu et al. recited above, as the Examiner cites Satou et al. only to teach "ICP plasma reactors having the claimed coil configurations (see figures 5 and 7)." Satou et al. does not teach or suggest directing radiation onto the substrate surface from directly above the substrate and through the wall of the process chamber, detecting radiation reflected from the substrate, collimating the detected radiation, and evaluating the detected collimated radiation, as claimed. It is not clear why one of ordinary skill in the art would be motivated to modify the chamber taught by Chiu et al. to the different type of chamber taught by Satou et al.. Similarly, there is no teaching or suggestion that would motivate one of ordinary skill in the art to apply the process monitoring system taught by Chiu et al. to the type of chamber and external antenna system taught by Satou et al.. In fact, since Chiu et al. indicates that detecting radiation is a problem even when the antenna coil surrounds sidewalls of the chamber, one would be motivated against applying an antenna that is above the external surface of the chamber as this would further

exacerbate the problem of monitoring the endpoint signal from directly above the substrate in the chamber, as claimed. Thus, Applicants respectfully submit that claim 1 is patentable over Chiu et al. and in view of Satou et al.

Furthermore, claim 1 is also not obvious over the combination of Chiu et al. and Satou et al., because the cited references do not motivate or teach the advantages of directing radiation from directly above the substrate and through the wall of the chamber, detecting the substrate reflected radiation, collimating the detected radiation, and evaluating the detected collimated radiation. Specifically, the present process substantially improves the signal-to-noise ratio of the endpoint signal obtained during processing of a substrate. This is because directing radiation from directly above the substrate and detecting the radiation also directly above the substrate, and then collimating the detected radiation to obtain radiation that primarily passes along the vertical direction, synergistically combine to maximize the signal strength of detected radiation that is reflected with a vertical incidence angle, and minimize radiation reflected from the substrate at other angles. This improves the endpoint detection signal from, and provides a more precise termination point for, the process being performed on the substrate in the chamber. Chui et al. and Satou et al. do not motivate the claimed processes because they do not recognize the advantages of the present process in terms of directing and receiving radiation from directly above the substrate to be vertically incident upon the substrate. Thus, Applicant respectfully submits that claim 1 is patentable over Chiu et al. and in view of Satou et al.

The combination of Chiu et al. and Satou et al. also does not teach or suggest claim 10 because the cited references do not teach or suggest directing radiation onto the substrate surface from directly above the surface of the substrate and through the external surface of the portion of the ceiling of the process chamber; detecting radiation reflected from the substrate from directly above the surface of the substrate after the radiation propagates through a window in the portion of the ceiling facing the substrate; collimating the detected radiation; and evaluating the detected collimated radiation, as claimed in claim 10.

Claim 17 is also not taught or suggested by the combination of Chiu et al. and Satou et al., because the cited references do not teach “directing radiation onto the substrate surface from above the at least partially domed external surface of the chamber; monitoring radiation reflected from the substrate from directly above a surface of the substrate after the radiation propagates through the at least partially domed external surface during processing of the substrate; collimating the detected radiation; and evaluating the monitored collimated radiation...” as claimed in claim 17.

Claim 21 is also not taught or suggested by the combination of Chiu et al. and Satou et al., because the cited references do not teach “directing radiation onto the substrate surface from directly above the surface of the substrate and through the external surface of the portion of the ceiling of the process chamber; collimating and monitoring radiation from directly above the surface of the substrate from after the radiation has propagated through the portion of the ceiling and external surface of the first enclosure facing the substrate and into a second enclosure disposed above the first enclosure; and evaluating the detected collimated radiation...” as recited in claim 21.

The combination of Chiu et al. and Satou et al. also does not teach or suggest claim 33 because references do not teach “directing radiation onto the substrate surface from directly above the surface of the substrate and through the wall of the process chamber; detecting radiation reflected from the substrate and propagating through the wall; collimating the directed and detected radiation; and evaluating the detected and collimated radiation...” as recited in claim 33.

Claim 38 is also not taught or suggested by the combination of Chiu et al. and Satou et al., because the cited references do not teach “directing radiation onto the substrate surface through the external top surface of the chamber; monitoring radiation reflected from the substrate and that propagates through the portion of the external top surface; collimating the monitored radiation; and evaluating the monitored radiation...” as recited in claim 38.

Claim 41 is also not taught or suggested by the combination of Chiu et al. and Satou et al., because the cited references do not teach "directing radiation across the flat wall of the chamber; detecting radiation that propagates through the flat wall; collimating the detected radiation; and evaluating the detected collimated radiation..." as recited in claim 41.

The combination of Chiu et al. and Satou et al. also does not teach or suggest claim 44, because the references do not teach "directing radiation onto the substrate surface through the wall of the chamber; detecting radiation reflected from the substrate and that propagates through the wall; collimating the monitored radiation; and evaluating the detected collimated radiation ..." as claimed in claim 44.

The combination of Chiu et al. and Satou et al. also does not teach or suggest claim 89, because the references do not teach "directing radiation onto the substrate through the wall facing the substrate; detecting radiation reflected from the substrate and that propagates through the wall using a monitoring assembly abutting an external top surface of the wall of the chamber; collimating the detected radiation; and evaluating the detected collimated radiation ..." as recited in claim 89.

For at least these reasons, the present claims are allowable over the cited combination of Chiu et al. and Satou et al..

II. The Examiner further rejected claims 8, 9, 24 and 25 under 35 U.S.C. § 103(a) as being unpatentable over Chiu et al. and Satou et al. as applied to claims 1 and 21 above, and further in view of Halle et al. (US 5,691,540).

Claims 8 and 9 are dependent on claim 1, and the combination of Chiu et al. and Satou et al. does not teach or suggest claim 1, for the reasons cited above. Specifically, Chiu et al. and Satou et al. do not teach applying an RF current through a multi-turn antenna above an external surface of a wall of the process chamber to pass RF energy through the wall of the process chamber to the gas inside the process chamber to energize the gas; directing radiation onto the substrate surface from directly above the substrate and through the wall of the process chamber; detecting radiation reflected from the substrate from directly above the surface of the substrate and after the radiation propagates through the wall; collimating the detected radiation; and evaluating the detected collimated radiation to monitor the depth of a layer being processed on the substrate, as recited in claim 1.

The Examiner indicates that Halle et al. teaches “a plasma process monitoring apparatus that includes a collimating lens and a bifurcated optical cable with [one] end being connected to the signal source and one end being connected to the signal detector,”

However, Halle et al. does not teach applying an RF current through a multi-turn antenna above an external surface of a wall of the process chamber to pass RF energy through the wall of the process chamber to the gas inside the process chamber to energize the gas. Applicant's claim 1 is directed to monitoring a process while current is being passed through a multi--turn antenna about an external surface of a wall of the chamber. Halle et al. does not teach energizing the gas by coupling RF energy to the gas through a wall of the process chamber while monitoring the process conducted in the chamber through the same wall, and consequently, does not disclose the claimed monitoring process and advantages of the claimed monitoring process.

The present claims are directed to solving the problem of monitoring the endpoint of a process being conducted in a chamber in which gases are energized by coupling RF energy through the wall of the chamber. Because the RF energy is being coupled from outside the wall into the chamber, the energy coupling step interferes with the step of monitoring the endpoint of the process, which is also being conducted through the same wall. Applicant has devised an elegant solution to this problem by directing radiation onto the substrate surface from directly above the substrate and through the wall of the process chamber while also detecting radiation reflected from the substrate from directly above the surface of the substrate after the radiation propagates through the wall. Further, the signal-to-noise ratio of the reflected radiation is improved by collimating the detected radiation and evaluating the detected collimated radiation, all in a vertically oriented direction. These processes, or the advantages obtained therefrom, are not taught or suggested by the combination of Chiu et al., Satou et al. and Halle et al.. Only in hindsight and coupled with the knowledge gleaned from Applicant's disclosure can the claimed combination be reconstructed based on selective extraction of individually relevant sections from each these references, which have little or no bearing on the claimed combination. For these reasons, claims 8 and 9 are not obvious over the cited references.

Claims 24 and 25 are dependent on claim 21, and the combination of Chiu et al. and Satou et al. does not teach or suggest claim 21, for the reasons cited above. Specifically, Chiu et al. and Satou et al. do not teach " directing radiation onto the substrate surface from directly above the surface of the substrate and through the external surface of the portion of the ceiling of the process chamber; collimating and monitoring radiation from directly above the surface of the substrate from after the radiation has propagated through the portion of the ceiling and external surface of the first enclosure facing the substrate and into a second enclosure disposed above the first enclosure; and evaluating the detected collimated radiation to monitor the depth of a layer being processed on the substrate to determine a process endpoint, as recited in claim 21.

Furthermore, Halle et al. does not make up for the deficiencies of Chui et al. and Satou et al. because Halle et al. also does not teach applying an RF current through a multi-turn antenna to pass RF energy from outside an external surface of a portion of the ceiling of the first enclosure facing the substrate to the process gas inside the first enclosure to energize process gas, as claimed in claim 21. Further, Halle et al. does not teach or suggest the problem of monitoring the endpoint of a process being conducted in the chamber through the same external surface of the chamber through which RF energy is passed from outside the chamber. As previously explained, the multi-turn antenna occupies space above the external surface of the ceiling and prevents monitoring of the process because of the volume of space occupied by the antenna. Applicant has devised an elegant solution to this problem by directing radiation onto the substrate surface from directly above the surface of the substrate and through the external surface of the wall of the process chamber, and collimating and monitoring radiation also from directly above the surface of the substrate after the radiation has propagated through the portion of the ceiling and external surface of the enclosure. The detected collimated radiation provides a higher signal-to-noise ratio for monitoring the depth of a layer being processed on the substrate to determine a process endpoint. The advantages of the present process, and more specifically, the problems solved by using the claimed monitoring process in combination with an RF energy coupling process through the ceiling is simply not taught or suggested by the combination of Chiu et al., Satou et al. and Halle et al.. For these reasons, claims 24 and 25 are not obvious over the cited references.

CONCLUSION

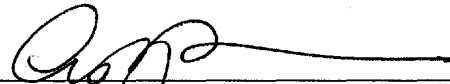
The above-discussed amendments are believed to place the present application in condition for allowance. Should the Examiner have any questions regarding the above remarks, the Examiner is requested to telephone Applicant's representative at the number listed below.

Respectfully submitted,

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